POGO MINE
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MINING DONE RIGHT

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December 12, 2013
COR-13-092
Hand Delivered

Director, Air and Waste Management Division
US Environmental Protection Agency
1200 Sixth Avenue
Seattle, WA 98101

Re: Sumitomo Metal Mining Pogo LLC (Pogo) Siting Analysis for CISWI Unit, 40 C.F.R. 60.2045(b).

Dear Sir or Madame:

Enclosed is a siting analysis for the solid waste incinerator operated by Sumitomo Metal Mining Pogo LLC (Pogo) at the Pogo Mine located near Delta Junction, Alaska. The incinerator is subject to the requirements of the Clean Air Act New Source Performance Standards (NSPS) for Commercial and Industrial Solid Waste Incineration (CISWI) Units, 40 C.F.R. Part 60, Subpart CCCC (Subpart CCCC).

Section §60.2045(b) requires that "the owner or operator must prepare a siting analysis for a CISWI unit which commenced construction after June 4, 2010." Pogo's incinerator commenced construction on December 8, 2010, prior to the effective date of the CISWI rule. As such, Pogo was not required to develop a siting analysis prior to commencing construction. To the extent it is required under these circumstances, Pogo is submitting one.

As required by §60.2050(a), Pogo's siting analysis considers air pollution control alternatives that minimize, on a site-specific basis, to the maximum extent practicable, potential risks to public health or the environment. In evaluating such alternatives, the analysis considers costs, specifically cost effectiveness, as well as energy impacts and other environmental impacts.

In evaluating the air pollution control alternatives, the use of optimum combustion control was determined to be the best control alternative to minimize potential risks to public health and the environment associated with the relatively low emission rates of D/F, NOx, and CO. Such combustion control is inherent to the design and operating procedures of Pogo's incinerator.

In its petition to EPA under Subpart CCCC §60.2115, Pogo identified specific operating parameters to be continuously monitored and limited to ensure continued optimal control of combustion.

The preferred control approach for metals emissions is removal/separation from the waste stream prior to incineration and Pogo's waste management procedures incorporate this approach.

Should you have any questions, please give us a call at 907-895-2879 or email us at sally.mcleod@smmpogo.com.

Sincerely,

Sally S McLeod

Sally S. McLeod, CEM, REM
Environmental Manager

Attachment: Siting Analysis – Pogo CISWI Unit

Cc: Heather Valdez, EPA
Zach Hedgpeth, EPA
John Pavitt, EPA
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John Rosburg, AECOM
Jeff Hunter, Perkins Coie
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SPECIALIZED
Environmental Solutions

Sumitomo Metal Mining Pogo, LLC
Siting Analysis - Pogo CISWI Unit

Submitted to:
Sumitomo Metal Mining Pogo LLC
Delta Junction, Alaska

Submitted By:
Specialized Environmental Solutions
Los Osos, California
December 2013

1.0 Introduction

Sumitomo Metal Mining Pogo, LLC (Pogo) commenced construction of a small, remote solid waste incinerator in December 2010. This incinerator is subject to Standards of Performance for Commercial and Industrial Solid Waste Incineration (CISWI) Units, set forth in 40 CFR 60 Subpart CCCC (Subpart CCCC). Section 60.2045(b) requires that "the owner or operator must prepare a siting analysis for a CISWI unit which commenced construction after June 4, 2010."

As specified in §60.2050(a), the CISWI unit siting analysis must consider air pollution control alternatives that minimize, on a site-specific basis, to the maximum extent practicable, potential risks to public health or the environment. In considering such alternatives, the analysis may consider costs, energy impacts, nonair environmental impacts, or any other factors related to the practicability of the alternatives.

2.0 Air Pollution Control Alternatives

This analysis considers available technologies used to control the pollutants subject to the applicable emission limits of Subpart CCCC, Table 8. In some cases, two or more pollutants may be controlled by one control alternative. In addition, certain control systems incorporate more than one control device to pre-treat exhaust gases or prevent secondary emissions. Table 2-1 presents a matrix of the subject pollutants and proven control alternatives applied at solid waste incinerators and other industrial combustion sources. Attachment 1 presents details calculations used for cost considerations.

2.1 Wet Scrubbers

Several types of wet scrubbers are used to control incinerator emissions. Wet scrubbers that are intended primarily for particulate matter (PM) control have the advantage of also controlling inorganic gases (e.g., hydrogen chloride (HCl) and sulfur dioxide (SO_2)), as well as some metal compounds (e.g., cadmium chloride ($CdCl_2$) and lead chloride ($PbCl_2$)) that may condense onto particulate matter. For control of PM and inorganic gases, venturi scrubbers and cyclonic spray towers are preferred over conventional spray towers. Venturi scrubbers can achieve relatively high collection efficiencies for PM with aerodynamic diameters in the 0.5 to 5 micron (µ) range [USEPA 2003a].

Packed bed wet scrubbers are also used for control of inorganic gases such as HCl and SO_2, and these scrubbers also remove some PM from the waste stream. Packed bed wet scrubbers are limited to applications in which dust loading is low.

TABLE 2-1
MATRIX OF SUBPART CCCC REGULATED POLLUTANTS AND AVAILABLE CONTROL ALTERNATIVES[1]

Pollutant	Wet Scrubber	Dry/Semi-Dry Scrubber	FF	ESP	Adsorbent Bed	Adsorbent Injection	SCR	SNCR
PM	X		X	X				
HCl	X	X[3]	Y[3]	Y[3]		X[3]		
D/F			Y[4]	Y[4]	X	X[4]		
Metals[2]	X		X, Y[5]	X, Y[5]				
Hg			Y[5]	Y[5]	X	X[5]		
NOx							X[7]	X[7]
SO_2	X	X[6]	Y[6]	Y[6]		X[6]		

X = Applicable control alternative for the listed pollutant
Y = Additional/secondary PM control equipment, necessary when the primary control alternative is dry scrubber, semi-dry scrubber or adsorbent injection (see table notes 3 - 6, below)
[1]The control alternatives most commonly used for MSW incinerators are shown in this table,
Where: FF = Fabric filter
ESP = Electrostatic precipitator
SCR = Selective catalytic reduction
SNCR = Selective non-catalytic reduction
Note: carbon monoxide (CO) is not listed above. CO control is generally achieved by optimum combustion controls rather than add-on control equipment. Optimum combustion control (inherent in the ACS incinerator design) is demonstrated/maintained by the operating limits established per §60.2115.
[2]Metals regulated in the CISWI rule include cadmium (Cd), lead (Pb), and mercury (Hg).
[3]If HCl emissions are controlled using a dry or semi-dry scrubber, particulate emissions are emitted from the scrubber and must be removed in a FF baghouse or ESP. If adsorbent injection is used (e.g., calcium compounds), a FF baghouse or ESP is needed to remove the adsorbent particles from the exhaust stream.
[4]If D/F emissions are controlled using adsorbent injection (e.g., activated carbon injection), a FF baghouse or ESP is needed to remove adsorbent particles from the exhaust stream.
[5]If mercury is controlled using adsorbent injection (e.g., activated carbon), a FF baghouse or ESP is needed to remove adsorbent particles from the exhaust stream.
[6]If SO_2 emissions are controlled using a dry or semi-dry scrubber, particulate emissions are emitted from the scrubber and must be removed in a FF baghouse or ESP. If adsorbent injection is used (e.g., calcium compounds), a FF baghouse or ESP is needed to remove the adsorbent particles from the exhaust stream.
[7]Primary NOx control techniques utilize air and temperature control; SCR and SNCR are secondary techniques.

High exhaust gas temperature can lead to excessive evaporation of scrubbing liquid and adversely affect the absorption of inorganic gases. For PM control, it would be necessary to reduce exhaust gas temperature to less than 700°F, and as low as 100°F for effective absorption of inorganic gases. For wet-scrubber application to this incinerator, pretreatment of the exhaust gas (e.g., pre-cooling in a spray chamber) would be required to reduce the temperature from around 1,400°F to less than 100°F.

Preliminary emissions testing of Pogo's incinerator indicated that uncontrolled emissions of PM (including any metal compounds condensed onto particles), are approximately 70 milligrams per standard cubic meter (mg/scm) [AECOM 2013]. These concentrations are far below the minimum pollutant loadings specified for venturi scrubbers: minimum PM loadings are typically greater than 1,000 mg/scm. For this reason, a venturi scrubber may not be an applicable alternative for Pogo's incinerator.

In addition, the minimum gaseous pollutant loading to packed bed scrubbers is typically 250 ppm or greater; this incinerator has combined, uncontrolled HCl and SO_2 emissions of approximately 165 ppm [USEPA 2003b, AECOM 2013]. These extremely low emissions indicate that a packed-bed wet scrubber may not be applicable to Pogo's incinerator. If a wet scrubber is used, however, very low removal efficiencies for PM and gaseous pollutants can be expected.

The EPA has published ranges for capital cost, operating cost, annualized cost, and cost effectiveness (expressed in 2002 dollars) for spray tower wet scrubbers of conventional design under typical operating conditions. The costs should be considered conservatively low since they do not include costs for post-treatment or disposal of used scrubbing liquid, or the costs of a pre-treatment gas quenching system. The EPA states that, as a rule, *smaller units controlling a low concentration waste stream will be more expensive* (per unit of volumetric flow) than a large unit cleaning a high pollutant load.

The EPA-estimated, conservative annualized cost for a wet scrubber is \$2.5 to \$48 per standard cubic foot per minute (scfm). Based on a flowrate of approximately 930 scfm and the high end of the cost range, the estimated annualized cost is \$44,640. Based on a control efficiency of 99 percent for PM, SO_2 and HCl (conservatively high given the low inlet loadings), the expected cost effectiveness[1] is approximately \$9,800 per ton of pollutant controlled. This value is significantly greater than the maximum cost-effectiveness described by the EPA for wet scrubbers (i.e., a range of \$45 to \$860 per ton). For this reason, the wet scrubber control alternative is considered economically infeasible [USEPA 2003b].

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[1] Cost effectiveness is the annualized cost per ton of pollutant controlled. The combined emission rate of PM, SO_2 and HCl was derived from preliminary emissions testing in June 2013 as follows: (0.9)(0.20 lb-PM/hr + 0.19 lb-SO2/hr + 0.66 lb-HCl/hr)(8,760 hr/yr) / (2,000 lb/ton) = 4.1 tons per year (tpy).
Cost effectiveness = (\$44,640/yr) / (4.1 ton/yr) = \$10,800/ton

Energy impacts of wet scrubbers are not addressed in this analysis. Adverse environmental impacts may be associated with this alternative, however, since waste is generated in the form of a slurry, which creates the need for both wastewater treatment and solid waste disposal.

2.2 Dry and Semi-Dry Scrubbers

Emissions of SO_2, as well as acid gases including HCl, may be controlled using dry and semi-dry scrubbing alternatives. These scrubbing processes typically use calcium or sodium based alkaline reagent. The reagent is injected into the flue gas in a spray tower or directly into the ductwork. The SO_2 and HCl are neutralized and/or oxidized by the alkaline reagent into a solid compound. The SO_2 reacts to form either calcium or sodium sulfate, and the HCl reaction forms either calcium or sodium chloride. This solid must be removed from the waste gas stream using PM control technology downstream [USEPA 2003c].

Semi-dry systems inject aqueous sorbent slurry and, as hot flue gas mixes with the slurry solution, water from the slurry is evaporated. Dry sorbent injection systems pneumatically inject sorbent directly into the furnace or downstream ductwork. In both systems, the dry waste product is removed using PM control equipment such a FF baghouse or electrostatic precipitator (ESP). The waste product can be disposed, sold as byproduct, or (in the semi-dry system) recycled to the slurry.

Typical pollutant loading concentrations are limited to approximately 2,000 ppm. The optimal inlet gas temperatures for semi-dry systems range from 300°F to 350°F, while dry injection system temperatures vary between 300°F to 1,830°F depending on the sorbent properties.

As stated previously, uncontrolled SO_2 and HCl emission concentrations are approximately 22 ppm and 140 ppm, respectively; due to these extremely low emissions from Pogo's incinerator, relatively low removal efficiencies can be expected for a dry or semi-dry scrubbing system.

Operating costs of semi-dry and dry scrubbers are generally considered to be greater than operating costs of wet scrubbers, due to the additional costs for reagent purchase, shipping, and disposal, as well as the need to employ a downstream PM control technology having its own operating costs for energy, maintenance, waste disposal, etc. The use of either system, combined with the secondary PM control system, would control approximately the same amount of SO_2, HCl, and PM as a wet scrubber and would have greater annualized costs than a wet scrubber. Because the wet scrubber was deemed economically infeasible (see Section 2.1, above), it follows that dry and semi-dry scrubbers are also economically infeasible.

As discussed for wet scrubbers, dry and semi-dry scrubbing alternatives may also have adverse environmental impacts associated with waste treatment and disposal.

2.3 Fabric Filters

Fabric filters (FFs) are commonly used to control PM emissions from industrial sources, including large solid waste incinerators. In addition, FFs can control some metal compounds (e.g., $CdCl_2$, $PbCl_2$) that condense onto particulate matter as the waste gas cools after exiting the incinerator. Well designed and operated FF baghouses are generally capable of achieving outlet PM concentrations of 0.01 grains per dry standard cubic foot (gr/dscf), or 23 mg/scm.

Exhaust gas temperatures up to 550°F can be accommodated routinely, with the appropriate fabric material. Because this incinerator's exhaust gas temperature is approximately 1,400°F, high temperature-resistant bags and/or a pre-treatment quench system would be required.

As discussed in section 2.1, the uncontrolled PM emission concentration from Pogo's incinerator (including any metal compounds condensed onto PM) is approximately 70 mg/scm. Typical FF inlet loadings range from 500 to 2,300 mg/scm, and in extreme cases inlet concentrations are as low as 100 mg/scm. In this application, PM loading would be 30 percent *below* the extreme-case minimum loading to FF control systems [USEPA 2003d]. For this reason, a FF system may not be considered applicable. If a FF alternative is used, very low PM removal efficiency can be expected.

The EPA has published ranges for capital cost, operating cost, annualized cost, and cost effectiveness (expressed in 2002 dollars) for typical FF systems. The estimated costs are based on a conventional design under typical operating conditions and do not include auxiliary equipment, pre-treatment quenching, or additional costs for FFs constructed of special, heat-tolerant materials. In general, *a small unit controlling a low pollutant loading (such as the Pogo unit) will not be as cost effective* as a large unit controlling a high pollutant loading [USEPA 2003d].

The EPA-estimated, conservative annualized cost for a FF is $42 to $266 per scfm. Based on a flowrate of approximately 930 scfm and the mean of the cost range, the estimated annualized FF cost is $143,000. Assuming 99.9 percent control efficiency (conservative given very low inlet loading), the FF alternative would have a cost effectiveness of approximately $160,000 per ton of PM controlled. The EPA predicts that cost effectiveness for FF systems to be in the range of $42 to $266/ton. For this reason, the FF control alternative is considered economically infeasible [USEPA 2003d].

2.4 ESP

Electrostatic precipitators (ESPs) may be dry or wet in design, and are capable of controlling PM, including fine particulates having aerodynamic diameters less than 2.5μ, and most metals (mercury is the notable exception since its emissions are primarily in the form of elemental vapor). An ESP uses electrical forces to move particulates entrained within an exhaust stream onto collection surfaces. The entrained particles are given an electrical charge when they pass through a corona, a region where gaseous ions flow. Electrodes in the center of the flow lane are maintained at high voltage to generate an electric field that forces the particles to the collector walls. In a dry ESP, the collectors are rapped or knocked by mechanical means to dislodge the particles, which slide downward and collected for disposal.

ESPs have very low pressure drops, resulting in low energy requirements, and they can handle gas temperatures up to 1,300°F. ESPs are have high capital costs, and can be difficult to install in sites with limited space since ESPs must be relatively large to achieve efficient collection.

Wet ESPs are used for applications not suited for dry systems, such as controlling materials that are wet, sticky, flammable, explosive, or high in resistivity. Wet ESPs use water flowing down the collector walls, and are therefore limited to inlet temperatures between 170°F and 190°F [USEPA 2003f].

Both wet and dry ESPs are not typically used for gas flows below 100,000 scfm; Pogo's incinerator has a gas flow rate of less than 1,000 scfm. This relatively low flow rate likely renders the ESP alternative technologically infeasible for this application.

The EPA has published ranges for capital cost, operating cost, annualized cost, and cost effectiveness (expressed in 2002 dollars) for typical ESP systems. The estimated costs are based on a conventional design under typical operating conditions. In general, *smaller units controlling a low concentration waste stream (such as the Pogo unit) will not be as cost effective* as a large unit cleaning a high pollutant load flow [USEPA 2003e].

The EPA-estimated, conservative annualized cost for a dry ESP is $35 to $236 per scfm. Based on a flowrate of approximately 930 scfm and the mean of the cost range, the estimated annualized ESP cost is $126,000. Conservatively assuming the maximum ESP control efficiency of 99.9 percent could be achieved, the estimated cost effectiveness for this application is greater than $120,000 per ton of PM controlled. The EPA predicts cost effectiveness to be no more than $236/ton for dry ESPs, and no more than $520/ton for wet ESPs. Therefore this control alternative is not considered economically feasible [USEPA 2003e,f].

2.5 Adsorbent Bed

Mercury (Hg) and dioxins and furans (D/F) emissions can be controlled by adsorption onto activated carbon (or other adsorbent) in a fixed bed system. The exhaust gas would require pre-treatment by a quench system to lower the temperature approximately 180°F and a venturi scrubber to remove larger PM (i.e., greater than 10μ in aerodynamic diameter).

Based on preliminary stack testing, this incinerator's Hg emissions are approximately 1 x 10^{-5} lb/hr, or 4 x 10^{-5} tpy. The total D/F emissions are extremely low, approximately two orders of magnitude less than Hg emissions. Based on the EPA-estimated annualized costs of $43,000/yr (for a 5,000-scfm adsorber), without correcting for Pogo's 930-scfm flow rate, and assuming 99.9 percent control efficiency *for PM* as well as D/F and Hg, cost effectiveness is approximately $49,000 per ton of pollutant controlled. This alternative is not economically feasible for this application [USEPA 1999].

The preferred Hg emission control approach is removal/separation from the waste stream prior to incineration. Pogo's waste management procedures incorporate this approach by applying strict requirements for separating (among other items) batteries, light bulbs, and electronic hardware from the solid waste. The preferred approach to minimize D/F emissions is optimum combustion control rather than add-on control equipment [Quina 2011]. Optimum combustion control is inherent in the ACS incinerator design and is achieved, in part, by the complying with operating limits identified in Pogo's petition developed per Subpart CCCC §60.2115.

2.6 Adsorbent Injection

An adsorbent such as activated carbon can be pneumatically injected into the combustion chamber or exhaust duct of the incinerator to control Hg and D/F emissions. This alternative also generates secondary PM emissions. As discussed in Section 2.5 above, the extremely small quantities of Hg and D/F to be controlled render the alternative economically infeasible for this application.

The preferred Hg emission control approach is removal/separation from the waste stream prior to incineration. Pogo's waste management procedures incorporate this approach by applying strict requirements for separating (among other items) batteries, light bulbs, and electronic hardware from the solid waste. The preferred approach to minimize D/F emissions is optimum combustion control rather than add-on control equipment [Quina 2011]. Optimum combustion control is inherent in the ACS incinerator design and is achieved, in part, by the complying with operating limits identified in Pogo's petition developed per Subpart CCCC §60.2115.

2.7 SCR

Selective catalytic reduction (SCR) is capable of NOx reduction efficiencies in the range of 70 percent to 90 percent. In the U.S., SCR has been applied to coal- and natural gas-fired electric utility boilers in size from 250 to 8,000 million British thermal units per hour (MMBtu/hr). For comparison, Pogo's incinerator has a combined heat input rating[2] of only 4.5 MMBtu/hr.

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[2] Rated heat input was based on: (1) three 0.8 MMBtu/hr rated propane burners and (2) the design waste heat content of 4,355 Btu/lb and the maximum design burn rate of 480 lb/hr.

Because this incinerator is very much smaller than the proven U.S. applications cited by the EPA, it is likely that SCR is not technologically applicable.

The NOx reduction reaction in the SCR is only effective within a given temperature range, depending on the type of catalyst used and the flue gas composition. Optimum temperatures vary from 480°F to 800°F, compared to an exhaust gas temperature of 1,400°F in the Pogo incinerator. For SCR control, the flue gas would require pretreatment quench to lower the temperature to the optimal range [USEPA 2003g].

The SCR process reduces the NOx molecule into molecular nitrogen and water vapor. A nitrogen based reagent such as ammonia or urea is injected into the ductwork downstream of the combustion unit. The flue gas mixes with the reagent and enters a reactor module containing a catalyst. The reagent reacts selectively with NOx within a specific temperature range and in the presence of the catalyst and oxygen.

Catalyst activity is a measure of the NOx reduction reaction rate, and is a function of several variables including catalyst composition, structure, diffusion rate, mass transfer rates, gas temperature and gas composition. Catalyst deactivation is caused by poisoning by flue gas constituents, thermal sintering due to high temperatures within the reactor, and blinding/plugging/fouling by ammonia-sulfur salts. Ammonia slip increases as catalyst activity decreases.

The EPA has published ranges for capital cost, operation and maintenance (O&M) cost, annualized cost, and cost effectiveness (in 1999 dollars) for SCR systems applied to industrial boilers and gas turbines. The EPA-estimated annual cost for a small gas turbine is $3,000/MMBtu. Based on the size of Pogo's incinerator, and neglecting additional costs for flue gas pretreatment, the estimated annualized cost for Pogo's incinerator is $13,500. A conservative estimate of cost effectiveness, assuming 90 percent control efficiency, is $8,000 per ton of NOx controlled. This high cost effectiveness indicates that SCR is economically infeasible for this application [USEPA 2003g].

Ammonia slip is a potentially adverse environmental impact. Ammonia slip refers to emissions of unreacted ammonia that result from incomplete reaction of NOx and the reagent.

Optimal combustion control is considered the preferred control alternative for sources that have very low uncontrolled NOx emissions [Quina 2011].

2.8 SNCR

Selective non-catalytic reduction (SNCR) can achieve NOx reduction levels of 30 percent to 50 percent. SNCR has been commercially installed on a variety of boiler configurations, as well as thermal incinerators, municipal and hazardous solid waste combustion units, cement kilns, process heaters, a and glass furnaces. In the U.S., SNCR has been applied to combustion units ranging in size from 50 to 6,000 MMBtu/hr. For comparison, Pogo's incinerator has a combined heat input rating of only 4.5 MMBtu/hr.

NOx reduction occurs at temperatures between 1,600°F and 2,100°F. SNCR tends to be less effective at lower levels of uncontrolled NOx; typical uncontrolled NOx levels vary from 200 ppm to 400 ppm [USEPA 2003h]. Pogo's incinerator has uncontrolled NOx levels of only 70 ppm [AECOM 2013].

SNCR is based on the chemical reduction of the NOx molecule into molecular nitrogen and water vapor. A nitrogen based reagent such as ammonia or urea is injected into the post combustion flue gas. The reaction with NOx is favored over other chemical reactions processes at temperatures between 1,600°F and 2,100°F; therefore, it is considered a selective chemical process. In the SNCR process, the combustion unit acts as the reaction chamber. The reagent is injected in a region immediately downstream of the main combustion zone, where the combustion gas temperature is at the required level. Certain applications are more suited for SNCR, including units with furnace exit temperatures of 1,550°F to 1,950°F, residence times of greater than one second, and high levels of uncontrolled NOx [USEPA 2003h].

Capital and operating costs of SNCR are lower than SCR costs, however, SNCR control efficiencies are about half those of SCR.

For the Pogo incinerator, the uncontrolled NOx concentration (i.e., 70 ppm) is well below the specified range for this control alternative (i.e., 200 to 400 ppm) and SNCR is not considered applicable to sources with such low NOx levels [USEPA 2003h]. Also, this incinerator is very much smaller than the proven U.S. applications cited by the EPA. Finally, adverse environmental impacts due to ammonia slip are associated with this process.

Optimal combustion control is considered the preferred control alternative for sources that have very low uncontrolled NOx emissions [Quina 2011].

3.0 Conclusions

This siting analysis considered air pollution control alternatives that minimize, on a site-specific basis, to the maximum extent practicable, potential risks to public health or the environment. In considering such alternatives, the analysis considered costs, specifically cost effectiveness, as well as energy impacts and other environmental impacts.

The use of optimum combustion control was determined to be the best control alternative to minimize potential risks to public health and the environment associated with the relatively low emission rates of D/F, NOx, and CO. Such combustion control is inherent to the design and operating procedures of Pogo's incinerator. In its petition to EPA under Subpart CCCC

§60.2115, Pogo has identified specific operating parameters to be continuously monitored and limited to ensure continued optimal control of combustion.

4.0 References

AECOM 2013 *Sumitomo Metal Mining Pogo, LLC Unit 412 Incinerator Test Report*. AECOM Environment, Fort Collins, Colorado, 60284905.1500, August 2013.

Quina 2011 Quina, Margarida J., João C.M. Bordado and Rosa M. Quinta-Ferreira (2011). *Air Pollution Control in Municipal Solid Waste Incinerators, The Impact of Air Pollution on Health, Economy, Environment and Agricultural Sources*, Dr. Mohamed Khallaf (Ed.)

USEPA 1999 *Choosing an Adsorption System for VOC.* United States Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA 456/F-99-004, May 1999.

USEPA 2003a *Air Pollution Control Fact Sheet (Venturi Scrubber)*, United States Environmental Protection Agency, EPA-452/F-03-017, 2003.

USEPA 2003b *Air Pollution Control Fact Sheet (Spray-Tower Scrubber)*, United States Environmental Protection Agency, EPA-452/F-03-016, 2003.

USEPA 2003c *Air Pollution Control Fact Sheet (Flue Gas Desulfurization)*, United States Environmental Protection Agency, EPA-452/F-03-034, 2003.

USEPA 2003d *Air Pollution Control Fact Sheet (Fabric Filter)*, United States Environmental Protection Agency, EPA-452/F-03-025, 2003.

USEPA 2003e *Air Pollution Control Fact Sheet (Dry ESP)*, United States Environmental Protection Agency, EPA-452/F-03-028, 2003.

USEPA 2003f *Air Pollution Control Fact Sheet (Wet ESP)*, United States Environmental Protection Agency, EPA-452/F-03-030, 2003.

USEPA 2003g *Air Pollution Control Fact Sheet (SCR)*, United States Environmental Protection Agency, EPA-452/F-03-032, 2003.

USEPA 2003h *Air Pollution Control Fact Sheet (SNCR)*, United States Environmental Protection Agency, EPA-452/F-03-031, 2003.

ATTACHMENT 1

COST EFFECTIVENESS CALCULATIONS

Cost Effectiveness Calculations
Pogo Incinerator Siting Analysis

Control Technology	EPA-Estimated Annualized Cost [1]		Pogo Process Rate		Pogo Annualized Cost ($/yr)	Pollutant Emission Rate lb/hr	tpy		Control Efficiency (%)	Cost Effectiveness ($/ton)
Wet Scrubber	48	per scfm	930	scfm	$44,640	1.1	4.6	[2]	99%	$9,805
Fabric Filter	154	per scfm	930	scfm	$143,220	0.20	0.88	[3]	99.9%	$163,657
Dry ESP	136	per scfm	930	scfm	$126,015	0.20	0.88	[3]	99.9%	$143,997
Adsorption Bed	$43,000	per year	930	scfm	$43,000	0.20	0.88	[4]	99.9%	$49,134
SCR	$3,000	per MMBtu	4.5	MMBtu	$13,500	0.42	1.8	[5]	90%	$8,154

[1] Annualized cost estimates were obtained from the EPA Air Pollution Control Fact Sheets listed in Section 4.0, References

[2] Potential emissions = sum of PM, HCl & SO_2

[3] Potential PM emissions only

[4] Potential emissions = sum of Hg, D/F & PM

[5] Potential NOx emissions only

Pogo Incinerator Emission Data

Pollutant	Emissions (ppm)	(lb/hr)
PM	na	0.20
HCl	142	0.66
SO_2	22	0.19
D/F	na	4.4E-10
metals*	na	2.7E-04
Hg	na	7.8E-06
NOx	70	0.42
CO	1.3	0.005

Source: June 2013 AECOM source test

*metals = combined emissions of CD, Pb & Hg, and represent quantities collected in the back-half of the RM29 sample train; therefore not controllable by FF or ESP